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Microscopic study of proton-nucleus total reaction cross sections

M El Shabshiry, M A Abdel-Rauf* and S Abdel-Rahim
Department of Physics, Faculty of Science, Ain Shams University, Cairo, Egypt

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Recently, De Vries and Peng (1979, 1980) drew attention to the fact that nuclear reaction cross section (σ_R) do not 'saturate' to a constant value as bombarding energy rises above the Coulomb barrier. Brink and Satchler (1981) studied the effects of the real potential on σ_R for ion-ion reaction at moderately low energies. Vitturi and Zardi (1987) modified the optical limit of the Glauber model to account for the Coulomb distortion of the trajectory occuring in the case of heavy ion scattering at relatively low energies.

In this work, the modified Glauber theory (Glauber 1959) is applied to study the effects of the repulsive potential (Coulomb plus centrifugal) on σ_R of protons scattered from ^{12}C and ^{208}Pb in the energy range 5-2500 MeV. This potential is introduced in the calculations when the impact parameter is replaced by the distance of closest approach. The effect of the central depression (ω) in the target density on σ_R is investigated by comparing σ_R calculated with Fermi density and σ_R calculated with three parameter density.

The basic point of the optical limit to the Glauber model is to express each partial wave phase shift as an integral along straight line trajectories, of quantities involving individual contributions of microscopic collisions weighted by the local matter density. According to Glauber theory, the imaginary part of the nuclear phase shift ($\text{Im}\, X_i$) for protons scattered from target nucleus of mass number A is given by

$$\text{Im}\, X_i(B) = {}^{1/2} A\sigma_{NN} \int^{\infty} \rho(B, z)\, dz \tag{1}$$

where $\rho(B, z)$ is the density of a single nucleon in the target. To study the effect of the central depression parameter ω, the density is taken in two forms :

(i) $\rho(r) = \rho_0/[1 + e^{(r-R)/a}]$, (2)

(ii) $\rho(r) = \rho_0 \left(1 + \omega \left(\frac{r}{R}\right)^2\right)/[1 + e^{(r-R)/a}]$ (3)

*Permanent address : Department of Theoretical Chemistry, University Erlangen-Nurnberg, D8520 Erlangen, FRG.

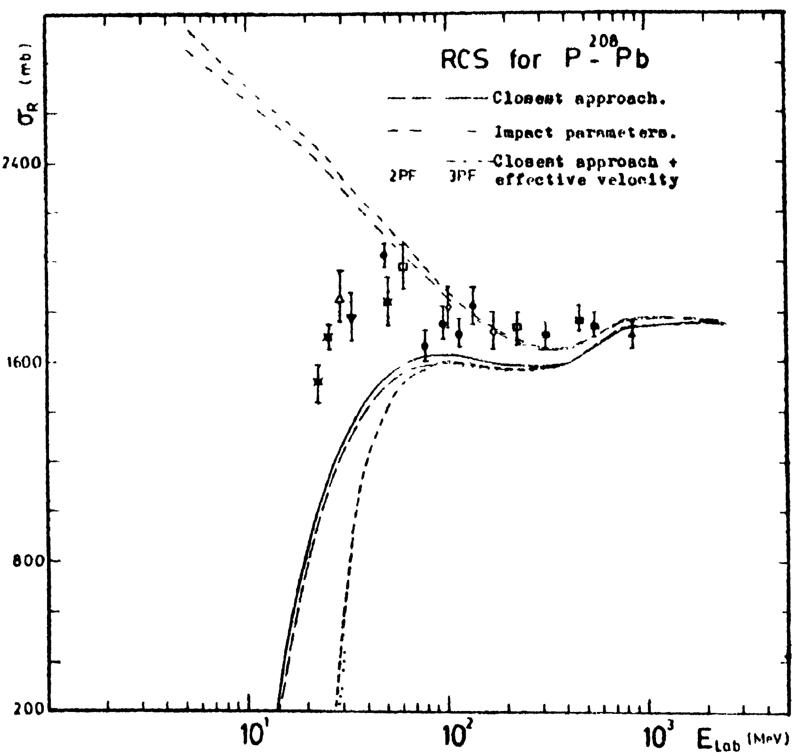

Figure 2. Same as in Figure 1 for proton-^{208}Pb scattering with Fermi density parameters $R_p = R_n = 6.62$ fm, $a_p = a_n = 0.54$ fm and the three parameters density has $R_p = R_n = 6.62$ fm, $a_p = a_n = 0.54$ fm and $\omega_p = -0.32$, $\omega_n = +0.32$. Data are taken from Menet *et al* (1969), Goloskie and Straush (1962), Renberg *et al* (1972), Ernst (1979), Digiacomo *et al* (1980), Gooding (1959), Renberg *et al* (1972) and Turber *et al* (1964).

From Figures 1 and 2, the effect of ω appears in the low energy range, which is large in case of $P-{}^{12}C$ reaction and small for $P-{}^{208}Pb$ reaction.

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